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Effect of crossbreeding and dietary neutral detergent fiber (NDF) levels on feed intake, nutrient digestibility, rumen parameters and nitrogen retention of beef cattle

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This experiment sought to evaluate the influence of varying levels of neutral detergent fiber (NDF) in the diet on feed intake, nutrient digestibility, rumen conditions, and nitrogen retention in crossbred cattle. Beef cattle aged 18 months were organized into groups using a 2x (4x4) Latin square design. The NDF levels investigated were 47%, 51%, 55%, and 59% of dry matter (referred to as NDF47, NDF51, NDF55, and NDF59 treatments, respectively). While dry matter (DM) consumption per 100 kg body weight (BW) did not exhibit significant differences between treatments, Charolais crossbred cattle (2.16 kg DM) demonstrated higher intake than Black Angus crossbred cattle (2.04 kg DM). Metabolizable energy intake in Charolais crossbred cattle significantly differed from that in Black Angus crossbred cattle (17.6 and 16.7 MJ/100 kg BW, respectively). Regarding NDF treatments, NDF47 did not differ from NDF51 and NDF55, but it was significantly higher ($P<0.05$) than the NDF59 treatment (18.1, 17.3, 17.1, and 16.0 MJ/100 kg BW, respectively). Although dry matter and organic matter digestibility did not significantly differ between Charolais and Black Angus crossbred cattle, variations were noted among treatments ($P<0.05$). Specifically, DM digestibility of NDF47 (62.8%) was significantly higher than NDF59 (55.4%), with no significant differences observed for NDF51 (59.8%) and NDF55 treatments (58.9%). Rumen pH, N-NH_3, and total volatile fatty acid concentrations at 0h and 3h post-feeding did not exhibit significant differences ($P>0.05$) in this study. However, nitrogen retention in Black Angus crossbred cattle was significantly lower than in Charolais crossbred cattle (0.124 and 0.166 g/kg BW, respectively). Across treatments, nitrogen retention values were numerically higher ($P>0.05$) in NDF47, NDF51, NDF55, and NDF59 treatments (0.166, 0.148, 0.139, and 0.126 g/kg BW, respectively). In summary, this study determined that Charolais crossbred cattle displayed increased feed intake, crude protein digestibility, and nitrogen retention compared to Black Angus crossbred cattle. Furthermore, a dietary NDF level of 55% was suggested as suitable for practical use in terms of feed utilization by farmers.

Keywords: Forage, crossbreeding, rumen fermentation, and ruminant.

***Abbreviations*:** DM: dry matter, OM: organic matter, CP: crude protein, NDF: neutral detergent fiber and ME: metabolic energy, BW: body weight. NDF47, NDF51, NDF55 and NDF59 treatment contained neutral detergent fiber at 47, 51, 55 and 59% (DM basis).

INTRODUCTION

In tropical developing nations, it is customary to employ locally accessible, economically feasible forages in the feeding practices for beef cattle (Paludo Ghedini *et al.*, 2021; EL-Mously *et al.*, 2023). Beef cattle have the capacity to utilize roughage and transform fiber into metabolic energy through the fermentation process facilitated by microorganisms (Mc Donald *et al.*, 2010).

***Crossbred cows*:** There are animals that arise from the intersection of two or more breeds with each other. Because each race has a unique set of characteristics, and we combine the characteristics of several races into one race (Lauvie *et al.*, 2008). Crossbreeding or distancing is simply called mixing two genuine and indigenous breeds and creating a new

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generation. There are many benefits to mixing, some of which include race (Swan *et al.*, 1992; Lauvie *et al.*, 2008):

1. through the mixing of the superior qualities of authentic male cows such as appearance, more milk production talent, more meat production talent and other hereditary characteristics, they are passed on to the next generation.

2.through the mixing of some inherited characteristics of native cows, such as resistance to diseases in the region and adaptation to the geographical conditions of the region, it is transmitted through the mother to the next generation.

So, the calf born through cross breeding has both some inherited characteristics of the original bull and some inherited characteristics of the Native female cow (Haskell *et al*., 2014; Basiel and Felix, 2022). In subsequent generations, gradually the traits transmitted from authentic cows appear in calves, and their production often increased by up to four times, and their meat production also increased significantly (Phillips, 2018). In this artificial insemination method for cross breeding, the sperm of the original and privileged Bull is first taken by special devices, which are called sperm extraction. After the sperm extraction of the original male cows in equipped laboratories, it is frozen and stored inside a gas. The animal's sperm is stored in liquid and solid form, and finally, using special tools, it is injected into their uterus during the estrus of Native female cows. Artificial insemination has none of the disadvantages of natural insemination. During estrus, symptoms such as jumping and riding with other cows, restlessness and discharge from the vagina are seen in the female cow, indicating her readiness to mate. The duration of estrus is about 30 hours, and if insemination is not performed during this period, the chances of a female cow becoming pregnant are reduced. The best time for artificial insemination in cows is half a day after the first symptoms of estrus occur (López-Gatius, 2022).

In Vietnam, the production of crossbred beef cattle, such as Angus, Charolais, Wagyu, involves artificial insemination between Zebu cattle groups and enhanced breeds. Despite the superior beef performance of crossbred cattle compared to local breeds, they exhibit a heightened demand for higher-quality diets (Favero *et al.,* 2019; Mwangi *et al.,* 2019). However, the advancement of production is hindered by the absence of tailored diets for each age period and breed group in fattening crossbred cattle. Recent findings by Truong and Thu (2020) reveal that a gradual increase in the neutral detergent fiber (NDF) level from 35.0% to 65.0% in the mixture results in a decline in in vitro organic matter (OM) and NDF digestibility. They propose that optimal treatments within the range of 47 to 59% NDF could be identified for future in vivo studies. Additionally, Rahman *et al*. (2009) observed an increase in the average weight gain of fattening cattle with improved NDF digestibility. Despite these insights, investigations into the dietary levels of NDF for crossbred cattle, with the aim of enhancing nutrition and beef performance, remain limited in Vietnam.

According to Mertens (2014), the key metric for evaluating the quality of ruminant feed is the neutral detergent fiber (NDF). NDF is identified as the fibrous component in the roughage cell wall, comprising polysaccharides such as hemicellulose, cellulose, and lignin. Furthermore, the cell wall contains a substantial amount of soluble protein derived from pigments or minerals, contributing to the nutritional value of the feed for ruminants (Chen, 2014). Harper & McNeill (2015) also emphasize the significance of NDF in serving as a source of metabolic energy, regulating rumen activity, and promoting saliva production, which, in turn, fills the rumen and induces contractions. The research of Combs (2016) highlights that the digestibility of NDF varies based on the feed sources and the specific animals involved.

Consequently, we propose a hypothesis that the collective impact of dietary NDF levels influences feed intake, nutrient digestibility, rumen parameters, and nitrogen retention in breeds of cattle.

MATERIALS AND METHODS

***Material*:** The research was carried out in the Tri Ton district of An Giang province, specifically at the Sau Duc cattle farm (coordinates: 10°29'33.6" N, 104°49'05.4" E), spanning from February 2020 to April 2020. The samples for analysis were processed at laboratory E205 within the Department of Animal Science at the College of Agriculture, Can Tho University.

***Experimental design*:** In this study, a double Latin square design 2x (4x4) factorial arrangement was employed, involving a total of 8 crossbred beef cattle. The cattle utilized in the experiments originated from two crossbreed sources: Black Angus x Zebu crossbred and Charolais x Zebu crossbred. The diet variations included different levels of neutral detergent fiber, specifically 47%, 51%, 55%, and 59% (referred to as NDF47, NDF51, NDF55, and NDF59, respectively). The chemical compositions of the feeds and diets are detailed in Tables 1 and 2.

***Feeds, feeding, and measurements taken*:** Elephant grass was cultivated on-site, while rice straw and *O. turpethum* vines were procured from local farmers. In this investigation, cattle were housed in individual cages to facilitate the convenient collection of feces and urine. Feed intake was assessed on a daily basis by weighing the provided feeds and measuring the leftovers. The animals received fixed quantities of concentrate, soybean meal, and urea twice daily, at 7:00 am and 1:00 pm. Additionally, O. turpethum vines, elephant grass, and rice straw were administered at 8:00 am, 10:00 am, 3:00 pm, 6:00 pm, and 10:00 pm. Water intake was measured before the morning feeding each day.

***Feed, nutrient, and energy intakes*:** The analysis of feeds and leftovers adhered to the AOAC (1990) procedure, encompassing parameters such as dry matter (DM), organic matter (OM), crude protein (CP), crude fiber (CF), and ether

Table 1. Chemical composition (%DM) of feeds.

Feeds	DM	OM	CP	NDF	ADF	CF	NFE
Elephant grass	16.5	88.5	9.04	64.4	40.4	32.3	42.1
O. turpethum vines	13.6	88.1	13.6	37.2	31.0	24.4	44.8
Rice straw	85.2	89.3	5.26	69.0	40.6	30.4	49.7
Soybean meal	86.6	93.8	42.0	18.1	14.6	04.8	44.8
Rice bran	89.1	89.1	11.7	27.4	15.3	10.3	58.9
Broken rice	84.9	99.4	8.29	7.03	2.14	1.06	89.0
Concentrate	87.8	89.8	18.1	20.1	11.9	6.73	60.0
Urea	99.6		286				

DM: dry matter, OM: organic matter, CP: crude protein, NDF: neutral detergent fiber, ADF: acid detergent fiber, CF: crude fiber, NFE: nitrogen free extract, NFE = OM – (CP + CF + EE).

Table 2. Ingredients (% DM) in different treatments of the experiment.

Dietary formula, %DM	Treatments			
	NDF47	**NDF51**	**NDF55**	**NDF59**
Elephant grass	10.0	9.92	9.73	9.36
O. turpethum vines	38.0	25.0	12.2	0.0
Rice straw	33.0	46.0	59.1	72.1
Soybean meal	0.00	1.98	2.92	5.62
Concentrate	19.0	16.9	15.6	12.2
Urea	0.000	0.238	0.559	0.735
Total	100	100	100	100
Chemical composition of diets, % DM				
DM	24.7	30.6	40.1	57.2
OM	88.3	88.3	88.1	88.1
CP	11.4	11.4	11.4	11.4
NDF	47.0	51.0	55.0	59.0
ADF	30.8	31.9	33.0	34.1
DM: dry				

extract (EE). Acid detergent fiber (ADF) and neutral detergent fiber (NDF) were determined using the method outlined b Van Soest *et al.* (1991). Additionally, the metabolizable energy (ME) content of the feeds was computed using the formula proposed by Bruinenberg *et al.* (2002). The calculation involved the equation ME (MJ/animal/day) = 15.1 x DOM (where DOM/DCP>7.0; DOM refers to digestible organic matter, and DCP denotes digestible crude protein) of the diets.

***Apparent nutrient digestibility and nitrogen retention*:** The apparent digestibility of dry matter (DM), organic matter (OM), crude protein (CP), neutral detergent fiber (NDF), and acid detergent fiber (ADF) was assessed using the methodology recommended by Mc Donald *et al.* (2010). Each experimental period spanned 14 days, with the initial 7 days allocated for dietary adaptation and the subsequent day designated for sampling. The nitrogen (N) content in the feeds, refusals, feces, and urine was determined through the Kjeldahl method (AOAC, 1990). Nitrogen retention was calculated using the daily collection of animal feces and urine.

***Rumen parameters*:** On the sixth day of each experimental period, specifically in the morning (midday), rumen fluid was extracted both before feeding (0h) and after feeding (3h) using a stomach tube. The collected samples were then subjected to analysis for pH, total volatile fatty acids (VFAs), and ammonia (N-NH_3). The pH of the rumen fluid was promptly measured using a portable pH device (EcoTestr pH2, Eutech – Singapore). The concentration of rumen ammonia was determined through distillation and titration, following the Kjeldahl method (AOAC, 1990). The analysis of rumen VFAs was conducted using the method outlined by Barnet and Reid (1957).

***Daily weight gains (DWG)*:** In the early morning before feedings at the beginning and at the end of each experimental period, the cattle were weighed (3 consecutive days) by an electronic scale (Model TPSDH, YAOHUA, Taiwan) and calculated live weights.

***Statistical analysis*:** The data were analyzed variance by using the ANOVA of General Linear Model (GLM) of Minitab Reference Manual Release 16.1 (Minitab, 2010). Differences between means were evaluated using a Tukey test of 5% of significance. The statistical equation for this model was $Y_{ijkl} = \mu + s_i + c_j + a_k + p_l + e_{ijkl}$; where: Y_{ijk}: observation from cattle, s_i: effect of Latin Square designs (i = 1, 2), c_j:

effect of neutral detergent fiber levels (j = 1, 2, 3, 4), a_k: the effect of crossbred cattle (k = 1, 2, 3, 4); p_l: the effect of period (l = 1, 2, 3, 4), and e_{ijkl}: residual effect.

RESULTS AND DISCUSSION

***Feed, nutrient and ME intakes of experiment crossbred cattle*:** Table 3 results reveal that the dry matter (DM) consumption of Black Angus crossbred cattle (2.04 kg/100 kg BW) was lower than that of Charolais crossbred cattle (2.16 kg/100 kg BW). This aligns with the findings of Finho *et al* (2016) who suggested a DM intake for crossbred cattle (300 kg) ranging from 1.94 to 2.18 kg/100 kg BW for a daily weight gain of approximately 0.5-0.75 kg/animal/day. However, DM intake did not exhibit significant differences (P>0.05) among treatments, with values of 2.10, 2.11, 2.11, and 2.09 kg/100 kg BW for NDF47, NDF51, NDF55, and NDF59 treatments, respectively. These results are consistent with those reported by Valero *et al.* (2015) ranging from 1.87 to 2.07 kg DM/100 kg BW. The daily crude protein (CP) intake (kg/100 kg BW) for Charolais crossbred cattle (0.243 kg) was significantly different from that of Black Angus (0.230 kg) (P<0.05). However, CP consumption did not show significant differences (P>0.05) among NDF levels. In contrast, the NDF intake was significantly different (P<0.05), ranging from 1.00 to 1.23 kg/100 kg BW for NDF47, NDF51, NDF55, and NDF59 treatments, respectively, demonstrating sensitivity to NDF consumption in the experimental design. Tham and Udén (2013) also suggested that NDF was the primary feed component regulating intake. The metabolizable energy (ME) consumption (MJ/100 kg BW) for Black Angus crossbred cattle was 16.7 MJ, lower than Charolais crossbred (17.6 MJ) (P<0.05). Furthermore, ME intakes across treatments were significantly different (P<0.05), decreasing from NDF47 to NDF51, NDF55, and NDF59 treatments, corresponding to 18.1, 17.3, 17.1, and 16.0 MJ/100 kg BW, respectively. Kongphitee *et al.* (2018) similarly concluded that ME intake decreased with increasing NDF levels (45.2 - 63.2%) in the diets. Water intake (kg/100 kg BW) tended to be higher in the NDF59 treatment (10.8 kg) than in the NDF47 treatment (8.08 kg). This increase in water intake could be attributed to a rise in the proportion of rice straw intake, which has low moisture content, and a decrease in O. turpethum vines in the diets. Consequently, the data presented indicate that the total nutrient intake of Charolais crossbred cattle was higher than that of Black Angus crossbred cattle. Moreover, Table 3 demonstrates a gradual reduction in ME intake with increasing NDF from 47 to 59% in the diets.

Apparent nutrient digestibility of experiment crossbred cattle: The dry matter (DM) digestibility for both Black Angus and Charolais crossbred cattle exhibited no significant difference (59.5% and 59.0%, respectively). However, DM

Table 3. Feed, nutrient, and metabolism energy.

Items	Crossbred cattle		Treatment				P		
	Black Angus	Charolais	NDF47	NDF51	NDF55	NDF59	Cr.cattle	Treat.	Cr.cattle x Treat.
Dry mater intake, kgDM/animal									
Elephant grass	0.676	0.672	0.672	0.672	0.675	0.678	0.898	0.998	0.998
O. *turpethum* vines	1.06	1.05	2.11	1.40	0.698	0.000	0.902	0.000	0.998
Rice straw	2.93	2.98	1.90	2.61	3.341	3.970	0.697	0.000	0.983
Soybean meal	0.161	0.160	0.000	0.116	0.175	0.351	0.929	0.000	0.999
Concentrate	0.938	0.933	1.091	0.977	0.923	0.753	0.898	0.000	0.998
Urea	0.019	0.020	0.000	0.122	0.029	0.036	0.642	0.000	0.992
Nutrient intake, kgDM/100 kgBW									
DM	2.04^{b}	2.16^{a}	2.10	2.11	2.11	2.09	0.000	0.905	0.832
OM	1.82^{b}	1.92^{a}	1.87	1.87	1.88	1.86	0.000	0.940	0.831
CP	0.230^{b}	0.243^{a}	0.235	0.236	0.238	0.238	0.000	0.516	0.903
NDF	1.09^{b}	1.15^{a}	1.00^{d}	1.08^{c}	1.16^{b}	1.23^{a}	0.000	0.000	0.707
ADF	0.677^{b}	0.718^{a}	0.661^{c}	0.688^{bc}	0.713^{ab}	0.730^{a}	0.000	0.000	0.765
ME*, MJ	16.7^{b}	17.6^{a}	18.1^{a}	17.3^{ab}	17.1^{ab}	16.0^{b}	0.022	0.004	0.991
Water, kg	8.87^{b}	9.73^{a}	8.08b	8.47^{ab}	9.87^{ab}	10.8^{a}	0.167	0.014	0.925
Output, kg/100 kg body weight									
Feces, kgDM	0.828^{b}	0.886^{a}	0.782^{c}	0.846^{bc}	0.868^{ab}	0.932^{a}	0.011	0.000	0.598
Urine, kg	4.48^{a}	4.13^{b}	5.32	4.67	3.84	3.373	0.538	0.090	0.922

DM: dry matter, OM: organic matter, CP: crude protein, NDF: neutral detergent fiber, ADF: acid detergent fiber, CF: crude fiber, NFE: nitrogen free extract, ME: metabolizable energy (MJ/kgDM), **Bruinenberg *et al.* (2002), BW: body weight. NDF47, NDF51, NDF55 and NDF59 treatment contained neutral detergent fiber at 47, 51, 55 and 59% based on dry matter.

a,b,c,d; Means within a row with different superscripts differ significantly (P≤0.05).

Table 4. Nutrient digestibility.

Items	Crossbred cattle		Treatment				P		
	Black Angus	Charolais	NDF47	NDF51	NDF55	NDF59	Cr.cattle	Treat.	Cr.cattle x Treat
Digestibility, %									
DM	59.5	59.0	62.8^{a}	59.8^{a}	58.9^{ab}	55.4^{b}	0.653	0.000	0.857
OM	60.9	60.6	64.2^{a}	61.2^{a}	60.4^{ab}	57.1^{b}	0.748	0.001	0.896
CP	65.4^{b}	69.3^{a}	69.8	66.6	66.9	66.1	0.002	0.121	0.871
NDF	58.4	59.3	60.0	59.1	59.0	57.1	0.556	0.626	1.000
ADF	47.7	47.9	51.4	48.1	47.1	44.5	0.921	0.129	0.993
Digestive nutrients, kgDM/100 kgBW									
DM	1.22^{b}	1.28^{a}	1.32^{a}	1.26^{ab}	1.24^{ab}	1.16^{b}	0.032	0.002	0.981
OM	1.11^{b}	1.16^{a}	1.20^{a}	1.15^{ab}	1.134^{ab}	1.062^{b}	0.022	0.004	0.991
CP	0.151^{b}	0.168^{a}	0.164	0.157	0.159	0.157	0.000	0.371	0.936
NDF	0.634^{b}	0.683^{a}	0.602^{b}	0.642^{ab}	0.688^{a}	0.703^{a}	0.031	0.010	0.981
ADF	0.323	0.343	0.340	0.331	0.336	0.325	0.200	0.914	0.992

DM: dry matter, OM: organic matter, CP: crude protein, NDF: neutral detergent fiber, ADF: acid detergent fiber. NDF47, NDF51, NDF55 and NDF59 treatment contained neutral detergent fiber at 47, 51, 55 and 59% based on dry matter.
a,b,c,d; Means within a row with different superscripts differ significantly (P≤0.05).

Table 5. Rumen pH, N-NH$_3$ and total volatile fatty acids (VFAs).

Items	Crossbred cattle		Treatment				P		
	Black Angus	Charolais	NDF47	NDF51	NDF55	NDF59	Cr.cattle	Treat.	Cr.cattle x Treat
pH									
0 h	7.09	7.03	7.12	7.08	7.04	7.01	0.150	0.251	0.955
3 h	6.98^{a}	6.87^{b}	6.90	6.97	6.93	6.91	0.000	0.226	0.253
VFAs									
0 h	68.5^{b}	83.7^{a}	74.3	73.0	76.9	80.2	0.001	0.627	0.666
3 h	77.9	93.0	84.1	82.6	85.0	89.9	0.007	0.767	0.949
N-NH$_3$									
0 h	18.5	16.0	17.5	18.6	16.0	16.8	0.073	0.572	0.769
3 h	22.3^{b}	19.5^{a}	22.3	21.2	19.8	20.3	0.026	0.501	0.622

NDF47, NDF51, NDF55 and NDF59 treatment contained neutral detergent fiber at 47, 51, 55 and 59% based on dry matter.
a,b,c,d; Means within a row with different superscripts differ significantly (P≤0.05).

digestibility for the NDF47 treatment (62.8%) was significantly higher than that for the NDF59 treatment (55.4%) (P<0.05). It did not differ significantly from NDF51 (59.8%) and NDF55 treatments (58.9%). These findings align with the results of Kongphitee *et al.* (2018) which ranged from 51.9% to 67.4%. Additionally, Konka *et al.* (2015) observed a decrease in DM digestibility from 57.8% to 55.5% with an increase in NDF from 55.4% to 66.2% in the diets. Organic matter (OM) digestibility varied significantly (P<0.05) among treatments, with the highest value observed in the NDF47 treatment (64.2%) and the lowest in the NDF59 treatment (57.1%).

This is in line with the findings of Truong and Thu (2020), who concluded that OM digestibility decreases with an increase in NDF in the diet, ranging from 47% to 65%. In ruminants, variations in the digestibility of fibrous feeds are influenced by differences in the concentration of cell wall carbohydrates. Although an increase in dietary NDF levels from 47% to 59% did not enhance the crude protein (CP) digestibility of crossbred cattle (66.1-69.8%), breed differences did affect nutrient digestibility. The CP digestibility of Black Angus crossbred cattle was lower than that of Charolais crossbred cattle (65.4% and 69.3%, respectively). Both neutral detergent fiber (NDF) and acid detergent fiber (ADF) digestibility tended to decrease from Charolais crossbred to Black Angus crossbred cattle. The decrease in NDF digestibility (P>0.05) with increasing dietary NDF levels can be attributed to the lower NDF content in O. turpethum vines compared to rice straw, leading to a reduction in the retention time of forage in the rumen. This aligns with the findings of Kongphitee *et al.* (2018) which ranged from 51.9% to 67.4%. ADF digestibility tended to be lower in the NDF59 treatment compared to other treatments. Sari *et al.* (2018) suggested that lower NDF content in plant feed materials, such as O. turpethum vines, could increase nutrient digestibility Brandao and Faciola (2019) recommended that 58% NDF in diets might not be adequate for high-producing animals. In summary, the digestibility of CP, NDF, and ADF (%) tended to decrease with incremental

Table 6. Daily nitrogen (N) retention of beef.

Items	Crossbred cattle		Treatment				P		
	Black Angus	Charolais	NDF47	NDF51	NDF55	NDF59	Cr.cattle	Treat.	Cr.cattle x Treat
N intake, g/animal/day	104.3	104.5	103.2	103.9	105.1	105.5	0.970	0.977	0.999
N fecal, g/animal/day	36.1[a]	32.3[b]	31.3	34.9	34.8	35.8	0.036	0.287	0.960
N urin, g/animal/day	33.4	27.5	26.3	28.6	31.8	35.1	0.146	0.432	0.994
N retention, g/kgBW	0.124[b]	0.166[a]	0.166	0.148	0.139	0.126	0.010	0.304	0.987
N retention, g/kgW0.75	0.507[b]	0.671[a]	0.676	0.600	0.568	0.512	0.014	0.323	0.989

NDF47, NDF51, NDF55 and NDF59 treatment contained neutral detergent fiber at 47, 51, 55 and 59% based on dry matter.
a,b,c,d; Means within a row with different superscripts differ significantly ($P \leq 0.05$).

NDF in diets from NDF47 to NDF59. However, DM and OM digestibility (%) were reduced in the present study.

Rumen parameters of experiment crossbred cattle: In this study, the concentrations of rumen pH, ammonia nitrogen (N-NH3), and volatile fatty acids (VFAs) at 0h and 3h post-feeding in experimental cattle did not exhibit statistically significant differences (P>0.05) across treatments. However, the pH values at 3h after feeding were lower than those recorded at 0h. The initial rumen pH values of the crossbred cattle at 0h aligned with those reported by Packer *et al.* (2011), ranging from 7.08 to 7.13. Both N-NH3 and VFAs concentrations at 3h after feeding surpassed those at 0h. The findings suggest that the incremental adjustment of dietary neutral detergent fiber (NDF) from 47.0% to 59.0% did not elicit a discernible impact on the rumen environment of the cattle.

Nitrogen retention of experiment crossbred cattle: The nitrogen intake exhibited no significant differences among treatments (P>0.05), ranging from 126 to 166 g/kg BW (Table 6). Fecal and urinary nitrogen demonstrated a gradual increase with rising dietary neutral detergent fiber (NDF) content, albeit without statistical significance (P>0.05). Consequently, nitrogen retention (g/kg BW) showed a tendency to decrease gradually (P>0.05) across the NDF47 to NDF59 treatments, with values of 0.166, 0.148, 0.139, and 0.139 g for the NDF47, NDF51, NDF55, and NDF59 treatments, respectively. Furthermore, Black Angus crossbred cattle exhibited higher fecal nitrogen (36.1 g) compared to Charolais crossbred cattle (32.3 g), though the difference was not statistically significant (P>0.05). As a result, nitrogen retention was significantly lower (P<0.05) in Black Angus crossbred cattle (0.124 g/kg BW) and higher in Charolais crossbred cattle (0.166 g/kg BW).

The nutrient consumption of Charolais crossbred cattle surpassed that of Black Angus crossbred cattle, while the dry matter (DM) intake across treatments did not exhibit any significant differences in this study. Notably, the neutral detergent fiber (NDF) intake for the NDF47 treatment was lower than that for the NDF59 treatment. Despite comparable dietary crude protein (CP) contents, the metabolizable energy (ME) intake experienced a significant decrease (P<0.05) with increasing NDF levels, with the highest value observed for the NDF47 treatment and the lowest for the NDF59 treatment. In line with these findings Trujillo *et al.* (2010) suggested that alterations in fiber digestibility in ruminants primarily stem from variations in NDF content within the diet. Additionally, Lee *et al*. (2019) elucidate that a diet low in fiber results in a decrease in the population of fiber-degrading bacteria, leading to an increase in lactic acid and volatile fatty acids (VFA), consequently lowering the pH. Galyean & Defoor (2003) further report that the NDF-to-forage ratio in the diet can serve as a predictor of the impact of a feed source on cattle DM intake, underscoring the utility of NDF as an influential factor in altering forage sources. In practical terms, achieving a low NDF content in beef diets may pose challenges in tropical and subtropical regions due to constraints related to nutritive value and genetics affecting beef growth. Harper and McNeill (2015) propose that, in tropical cattle systems, aiming for a higher NDF content in the diet may be a more pragmatic objective. This current experiment underscores the influence of NDF levels in the diet on digestibility.

***Conclusion*:** This study has revealed that Charolais crossbred cattle exhibited a propensity for enhanced forage utilization, nutrient digestibility, and nitrogen retention compared to Black Angus crossbred cattle. The incremental elevation of neutral detergent fiber (NDF) in the diets, ranging from 47.0% to 59.0%, exhibited a diminishing trend in nutrient digestibility, nitrogen retention, and daily weight gain in crossbred beef cattle. A NDF level of 55% in the diet emerged as a promising threshold for application. The potential benefits include an upturn in the utilization of fibrous roughage, improvements in rumen parameters, and enhanced daily weight gain.

***Authors' Contribution*:** Truong N.B and Thu NV conceived and designed the experiments; Truong N.B performed the experiments; Truong N.B and Thu NV analyzed the data; Truong N.B and Thu NV wrote the paper; all authors reviewed and approved the final manuscript.

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